canusa

Newsletter

Canada
United States
Spruce Budworms
Program

NUMBER 6, SEPTEMBER 1979

Spruce Budworms In The Pacific Northwest

Three species of budworm in the genus *Choristoneura* are common defoliators of Douglas-fir, true firs and spruce in western Canada and the western United States. The most common species, the western spruce budworm *(C. occidentalis* Freeman) is found from central British Columbia to New Mexico and Arizona and in all western states except Nevada. Defoliation by this species has occurred on a wide range of hosts: Douglas-fir, white fir, grand fir, Pacific silver fir, subalpine fir, western larch, Engelmann spruce, white spruce and blue spruce.

The geographical distribution of the other species is much more limited. The two-year budworm *(C. biennis* Freeman) occurs at high elevations on alpine fir and Engelmann spruce in southeastern B.C. and southwestern Alberta, whereas the western spruce budworm is found at low elevations on Douglas-fir. In central B.C., the ranges of the hosts overlap and it appears that the ranges of both insect species also overlap. Host 'preference' plus the occurrence of the second diapause in the IV instar appear to be the only distinguishable features between the insect species with the former being the basis of the distributions indicated on the map. The life cycle of individuals in any two-year budworm population is synchronized so that all moths appear in one year. The flight year of most populations is on the even years; i.e., 1978, 1980, etc. Recently, in the Purcell Range of mountains, populations have been found that have synchronized flights in the odd years. Outbreaks of two-year budworm have occurred sporadically with noticeable defoliation occurring every second year when the large larvae were present.

A third species, Modoc budworm, *C. viridis* Freeman, is found only in south-central Oregon and in northeastern California on white fir. The first outbreaks were recorded in 1941 and 1942 in the Warner Mountains, Oregon. Additional outbreaks were reported in 1947, 1958 to 1963 and 1972 to 1977.

Other species are present: *C. orae* occurs on Pacific silver fir and Sitka spruce on the north coast of British Columbia, and there is a large complex of species, including *C. lambertiana,* on *Pinus sp.* in the western United States, but they have caused relatively little damage.

Among the three common species, the western spruce budworm is the most destructive. The first recorded outbreak of this budworm was in 1909 on southern Vancouver Island, B.C. Analyses of tree rings in B.C. have indicated periods of reduced growth, probably because of budworm, for the periods 1916-18, 1927-35, 1942-48, 1955-63 and 1969-78. Sometimes stands have been attacked only once, while others have received up to five attacks over the last 90 years. Most defoliation has occurred in the Lillooet and lower Fraser Valleys, a maximum of 80,500 hectares being affected in 1958 and 244,000 hectares in 1977.

Before 1943, the western spruce budworm was one of many insects living in the forests of Washington and Oregon that occasionally flared up without causing much concern. Two small outbreaks in 1929 and 1931 collapsed within a year; but after 1943, its importance as a major forest pest increased. The first outbreak of consequence was in the Methow Valley in north-central Washington; an estimated 80,900 hectares of Douglas-fir and Pacific silver fir were defoliated to varying degrees before the outbreak collapsed in 1948. In 1944, an outbreak began in the Blue Mountains in northeastern Oregon and southeastern Washington. By 1948, budworm outbreaks were also reported in Oregon on the eastern and western slopes of the Cascade Mountains. They persisted for 20 years and eventually involved nearly 2 million hectares of Douglas-fir host type. Outbreaks in the Cascade Mountains were terminated in 1953 by an aerial application of insecticides.

Most of the area infested within Oregon and Washington has been subjected to only one outbreak since 1947. The three exceptions are: the Methow Valley, Washington, 1943 to 1948 and 1970 to the present; Warm Springs Indian Reservation, Oregon, 1948 to 1952 and 1974 to the present; and the Blue Mountains, Oregon, 1944 to 1956 and 1970 to 1975.

Data are limited on susceptibility to attack and vulnerability to damage of particular tree species and forest types. Defoliation has been observed in mixed as well as pure stands of Douglas-fir, in mature and immature stands, and in areas with an overstory of mature ponderosa pine and an understory of Douglas-fir. In steep mountainous terrain, defoliation is heaviest at mid-slope. During the 1970-78 outbreak on the east slopes of the Cascade Mountains in the USA and Canada, most of the defoliation occurred at between 600 and 1200 metres elevation even though there was host-type above and below this zone. Outbreaks have generally been on the east side of the Cascade Mountains where a lee effect results in a relatively dry environment compared to the coastal stands west of the Cascades.

In eastern Oregon and Washington, grand fir is more vulnerable to western spruce budworm feeding than Douglas-fir or Engelmann spruce. Larger proportions of grand fir in mixed conifer stands result in greater damage from western spruce budworm, and the competitive position of grand fir, relative to Douglas-fir and Englemann spruce, is reduced by top-killing. By contrast, in southern B.C., Douglas-fir is the primary host, and grand fir is not even a component of the forest where budworm outbreaks have occurred. But again, stand age or density or mixture seem to have little influence on location of defoliation; topography appears to be the dominant factor.

Douglas-fir is fairly resilient to the effects of defoliation. It readily produces adventitious buds which allows for a rapid regrowth of the crown when the outbreak subsides. Mortality is sporadic, occurring in a few mature stands where populations are abnormally high. Permanent tree damage, such as top kill, reduced height and diameter growth, generally does not occur until after a few years of continuous moderate defoliation.

After many years of outbreak conditions, a wide range in level of defoliation is evident among stands and among trees within stands. Ground cruises indicate that, on an average, about 54 percent of the trees retain more than 50 percent of their total foliage, 30 percent are 51 to 70 percent defoliated and 12 percent are 71 to 90 percent defoliated. On about half the trees that had sustained heavy defoliation for several consecutive years, radial increment had decreased, height growth had terminated and dieback had occurred. Some trees develop a fork or crooked stem as they recover.

Several natural factors, such as parasites, predators and climatic conditions, affect budworm populations. But the combined effect of natural factors cannot be relied upon to prevent an outbreak when conditions are favorable for an increase in budworm population. During prolonged outbreaks, starvation can be an important factor in reducing budworm populations.

To date, at least 40 species of primary parasites of budworm have been found, about 10 species exerting most control. In general, however, parasitism has not been a major mortality factor when budworm populations are in outbreak status.

Some of the more common predators of the budworm include ants, spiders, snakeflies, true bugs and larvae of certain beetles. Evening grosbeaks, cedar waxwings, warblers, thrushes and sparrows have been seen feeding on the budworm.

Although several pathogens have been found infecting the budworm, mortality from disease has been very low.

Climatic conditions may affect budworm populations in several ways. Cool, wet summer weather retards feeding and insect development, and sudden freezing temperatures in the spring, when the buds or new shoots are killed, will cause larval mortality through starvation. Windy conditions at the time larvae hatch from eggs or are leaving hibernation quarters may disperse larvae; winds and frontal disturbances can also disperse moths over a wide area.

It is not known if budworm outbreaks can be prevented through silvicultural treatment of stands. The budworm feeds on trees of all age classes and sizes and, because the preferred tree species are closely intermingled, little hope is held for such methods of control.

Before 1947, there was no need for direct control of the western spruce budworm since the outbreaks involved only a few hundred hectares and they collapsed within a year or two from natural control factors. However, in Oregon and Washington in 1947, with nearly 400,000 hectares infested and no evidence of a decline, direct control with chemical insecticides became a necessity to prevent further top-killing, growth loss and tree mortality.

Eleven control projects have been carried out against the western spruce budworm with the objective of reducing populations sufficiently to prevent additional damage for the term of an outbreak. The strategy has been to delay spraying until the buds flare so as to maximize larval exposure to the spray deposit; with Douglas-fir, this usually occurred when 50 percent of the larvae had developed to the V instar and older. Since Douglas-fir can withstand some defoliation, some bud kill and defoliation was accepted during the year of application in order to obtain better population control. The rough mountainous topography offers some degree of isolation among valley populations and, where possible, all populations in a valley have been sprayed during the same year rather than treating selected stands within the outbreak, thus minimizing the risk of moth re-invasion.

TABLE 1
Spruce budworm control projects in Oregon and Washington from 1949 to 1977

Year	Area Treated M hectares	Percent Larval Mortality Average	Range	Cost per Hectare $
1949[1]	108	97.6	88.9-100	2.97
1950	378	99.2	90.4-100	2.62
1951	375	98.6	74.0-100	2.62
1952	269	98.2	81.8-100	2.57
1953	149	99.1	88.5-100	2.35
1954	27	99.0	96.3-100	2.30
1955	251	96.9	79.0-100	2.62
1958	331	96.2	70.1-100	1.71
1962	19	99.1	97.4-100	2.84
1976[2]	145	84.3	75.7-92.2	11.32
1976[3]	3	96.2	80.6-100	18.98
1977[3]	144	91.7	88.2-94.1	16.53

[1]DDT was used on all projects during 1949-1962, applied at the rate of 1.12 kg per 9.35 L fuel oil per hectare by small fixed-wing aircraft.
[2]Malathion ULV was used, applied at the rate of 949 ml per hectare by helicopter.
[3]Sevin 4 oil was used, applied at the rate of 1.12 kg per 4.68 L fuel oil per hectare.

Nine control projects between 1949 and 1962, involving nearly 1.9 million hectares, were undertaken using DDT at 1.12 kg per 9.35 L of fuel oil per hectare. The remaining two projects were carried out during the current outbreak cycle. In 1976, Malathion ULV was used on 14,878 hectares and in 1977 SEVIN 4 Oil was used on nearly 144,472 hectares. The percent mortality obtained and cost per hectare of these 11 projects are shown in Table 1. A high degree of success was obtained between 1949 and 1962, because less than 1 percent of the areas had to be re-treated. Success was not as high in 1976; about one third of the area treated with Malathion was effectively retreated in 1977 with SEVIN 4 Oil.

Direct control of the Modoc, two-year cycle or other budworms has not been required. All outbreaks have collapsed naturally before significant amounts of tree damage occurred.

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Eastern U.S.

Northeastern Area (NA) State and Private Forestry, U.S. Forest Service, is an important cooperator in the Eastern Program. Forest Insect and Disease Management, in particular, has a lead role. One of its significant contributions has been the assumption of major responsibility for soliciting and reviewing demonstration proposals. Demonstration projects are well-planned innovative designs to encourage the user to adapt new technology to normal operations or, by redesigning the use of existing technology, to stimulate more efficient and comprehensive solutions to pest management problems. Hands-on user participation in project management is usually the key to a successful proposal, though workshop formats may be more suitable for some types of projects.

In November 1978, NA-S&PF formed a Demonstration Steering Committee. Its purpose is to evaluate demonstration project proposals. The Director of FIDM and the Eastern U.S. Program Manager make final funding decisions based on committee recommendations. Funding, which is shared by the Eastern U.S. Program and NA-S&PF, is intended to minimize management risks associated with novel approaches and to partially reimburse professionals and scientists for time and talents contributed to the projects. If Forest Service personnel are involved, their contribution is not factored into the budget of the project. In 1979, there have been 8 successful proposals.

Joint B.t. Committee

Ozzie Morris, CFS, and Don Seegrist, USFS, met at FPMI Headquarters in Sault Ste. Marie in July to discuss spray deposit card analysis from recently conducted B.t. operations in Eastern Canada and Maine. The full ad hoc committee meets later to discuss preparation of a report on '79 operations.

Western Pheromone Distruption Test

In 1979, CANUSA-West conducted a series of small aerial tests to evaluate the release capabilities of a controlled-release formulation of the western budworm pheromone. The study was led by Gary Daterman of the U.S. Forest Service, Corvallis, Oregon, and Roy Shepherd of the Canadian Forestry Service, Victoria, B.C. Lonne Sower and Charles Sartwell, U.S. Forest Service, Corvallis, are cooperators.

The pheromone formulation was prepared by the Hercon Division of Herculite Products Corp., New York, N.Y., and applied from a fixed-wing aircraft fitted with a special dispensing apparatus.

The test was conducted on relatively small plots and, consequently, damage reduction was not a criterion for efficacy evaluation. Effectiveness of treatments was judged on the degree that male moths were disoriented in locating live females, female-baited traps, and traps baited with synthetic pheromone. The objectives of the test were: (1) to determine the duration of effectiveness of the formulation; (2) to evaluate the effects of various dosages of the pheromone; (3) to observe movement of females within and from outside the treated plots. A secondary objective, changes in egg densities before and after treatment, was evaluated. Results of the trials will be reported later.

Spruce Budworm Suppression Activities In The United States In 1979

All of the 1979 cooperative State/Forest Service spruce budworm suppression projects have been completed and post-control evaluations are being made to determine if project objectives were achieved. A summary of the areas sprayed and insecticides used follows:

State	*Acres Sprayed*	*Insecticide(s) Used*	*Date Completed*
Maine	2,900,000	Sevin 4 Oil, Orthene Forest Spray, B.t., Dylox-4	June 19, 1979
Idaho	140,000	Sevin 4 Oil, Orthene Forest Spray	June 29, 1979
Oregon	34,440	Sevin 4 Oil	July 3, 1979
Total	3,074,440		

Originally 3.5 million acres were targeted for aerial spraying in Maine to protect forest resources. but only about 2.9 million acres were actually treated because of adverse weather and intense public pressure to widen buffers around communities and sensitive areas.

A group of citizens filed a complaint in Federal Court challenging the NEPA (National Environmental Policy Act) process and Federal financial participation in the 1979 project in Maine. Litigation is in progress.

An integrated pest management approach was used in Idaho this year. About 140,000 acres of the one-half million acres infested were treated to prevent excessive tree damage. Orthene Forest Spray was used in the more environmentally sensitive areas and along streams, and Sevin 4 Oil was used in the less sensitive areas. National Forest lands were sprayed only where necessary to prevent budworm reinvasion of treated private and State lands. On National Forests, the primary treatment strategy involves shifting timber harvesting from uninfested areas to unsprayed infested areas. This permits timely salvage of the insect-damaged timber and reduces the amount of budworm-susceptible timber over the long term.

Results of the post-control evaluations on all spray projects and the 1979 detection surveys in the United States will be reported in a later CANUSA Newsletter.

Reports Available

For a report entitled *A Pilot Project with Orthene for Control of the Western Spruce Budworm, McCall, Idaho 1977* write to the Director, Forest Insect and Disease Management, USDA Forest Service Region 4, Federal Building, 324 25th Street, Ogden, Utah 84401.

Great Lakes Forest Research Centre, Box 490, Sault Ste. Marie, Ontario, P6A 5M7, has released two recent reports, O-X-284 and 285: *Root Rot of Spruce and Balsam Fir* by R.D. Whitney and *Spruce Budworm Mating Disruption Trials* by C.J. Sanders. The Forest Pest Management Institute at the same posted address has released reports FPM-X-19 and 24: *Applications of experimental IGR's* by Retnakaran et al. and *Inoculation of SWB cell cultures with a microsporidian* by Wilson et al.

The Maritimes Forest Research Centre has published reports M-X-95, 96 and 97: *Condition of forests on Cape Breton Island* by L.P. Magasi, *Toxicity of Aminocarb to stream insects* by D.C. Eidt, and *Fir mortality on Cape Breton Highlands* by D.A. MacLean.

Copies of two special reports are available from the USDA Forest Service, Equipment Development Center, Missoula, Montana 59801: *Deliverable dose index: An approximate method for comparing effectiveness of pesticide droplet sizes* and *Forest and range aerial application technology: A problem analysis.*

Spruce Budworms Bibliography Available

In Issue No. 5 we announced the publication of the "Spruce Budworms Bibliography", a printed version of a USDA Forest Service computer file of more than 1,500 citations and abstracts of literature on the spruce budworms. This publication is now available from National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161. The NTIS Accession Number is PB297124/AS and the price is $19.00 for paper copies and $3.00 for microfiche.

Spruce Budworms At The International Congress of Plant Protection

A perusal of the program for the IX International Congress of Plant Protection, held in Washington, D.C., August 5-11, identified two contributed papers on spruce budworms: "Nitrogen fixation by the western spruce budworm: its implications in forest ecosystems" by G.B. Pitman and D.A. Perry; and "Results of treatments with *Bacillus thuringiensis* against the spruce budworm" by W.A. Smirnoff.

R&D Inventory Update

The CANUSA R&D Management Inventory is a computer-based file of information on studies and projects on spruce budworms in Canada and the United States. Issue No. 1, distributed last March, indexed 188 studies involving over 200 investigators for the benefit of investigators and Program Management.

October 1 is the target date for distribution of Inventory Issue No. 2. The existing file will be expanded by the new studies initiated in 1979 *to the extent that we have been provided information.* All investigators in Canada and the United States — in any institution, agency, or industry — conducting studies tests or projects (other than fully operational survey and control projects) on the spruce budworm or western spruce budworm in 1979 are urged to provide basic information on their work to CANUSA Program Management. For more information, contact Buckner (613-997-2175) or McKnight (703-235-8230).